Cardiovascular, Respiratory Impairments and Aquatic Therapy

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Learning Priorities

- Describe the direct impact of immersion to the cardiovascular and pulmonary systems and the current evidence to support aquatic care
- List and describe the various methods and reasons for supervision of cardio-pulmonary activities in the aquatic environment
- Compare and contrast the relative effort between various aquatic cardiopulmonary activities
- Explore opportunities to create meaningful cardiopulmonary treatment in the aquatic environment
- Identify meaningful goals and effective treatment interventions for cardiopulmonary populations in the pool

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PHYSIOLOGIC RESPONSE TO IMMERSION

Chest Water Immersion	Neck Immersion	Warm Water Immersion
Increased hydrostatic pressure increases venous and lymphatic compression	Increased Central blood flow and Increased chest/abdominal compression	Parasympathetic response
Central Blood flow and cardiac volume increases		Tone reduction
Stroke volume increases and heart rate decreases		Increase relaxation
Cardiac output increases	60% increased work of breathing	Decrease blood pressure
Increased diuresis		Increase peripheral blood flow

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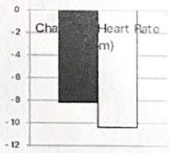
Heart Rate Change after Immersion Past Pool Course Data Summary

(data collection from past CCC classes)



Heart Rate decreases 3-17 b/m due to baroreceptor response to the increased centralized blood volume

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General Foundational Research about Aquatics and CP: Older and Newer

- Kosonen T., et al. 2006
  - Examined healthy vs. cardiac compromised women with 6 basic aquatic aerobic exercises
  - Evaluated HR, VO2max, blood lactate concentration, RPE
  - Walking in place in water – easiest; cross country skiing – most challenging
  - Aquatic exercise is appropriate for cardiac conditioning
- Jug B, et al. 2022.
  - Compares the impact of short-term 14-day water- and land-based exercise training on heart rate variability (HRV), an important indicator of heart health
  - Improved selected HRV parameters, suggesting this mode of exercise is safe and may be beneficial in patients with CAD.

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Cardiovascular-Aquatic Treadmill Training

'Aquatic treadmill training but not land treadmill training significantly reduced blood pressure and pulse pressure during stages of exercise stress and recovery. Increase in skeletal muscle endothelial nitric oxide synthase after training occurred in only the aquatic group. Both groups had body mass and VO2 improvements.'

2014 – Lambert et al (sedentary adults)

Underwater treadmill training superior to land treadmill training in improving affected weight bearing, stance phase and emotional aspect.

2014 – Park et al (Post Stroke)

"Aquatic treadmill exercise that incorporates balance and high intensity training (RPE – 14-19) effective at managing symptoms of OA

2014 – Bressel et al (adults with OA)

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Cardiovascular- Aquatic Ex/ Swimming

'Water exercise swimming program holds potential for social improvement.'

2010 – Pan et al (Autism)

'Aquatic programs ... can have positive effects on improving physical fitness and social behavior in children with CP...a variety of exercise can be used...swimming is the most common'

2012 – Jorgic et al (cerebral palsy)

'Running, cycling, and swimming groups resulted in a significant decrease in BMI. The quadriceps peak torque increased in the swimming and cycling groups. Total cartilage volume decreased in the running and cycling groups after 12 weeks of training, without any significant change in the swimming, powerstriding, and control groups.'

2014 – Lu et al (healthy young adults)

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Cardiovascular - Deep Water Jogging

Deep water running as effective as land-based exercise regarding pain however, it has more advantages related to emotional aspects.

2006 – Assis et al (fibromyalgia)

High intensity deep water running with wet vest improves submaximal work capacity, maximal aerobic power, and maximal ventilation with the effects transferable to land-based activities'

2006 – Broman et al (Elderly women)

'Addition of deep water running to general practice was more effective in reducing pain and disability than standard general practice alone'

2012- Cuesta-Vargas et al (chronic LBP)

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Cardiovascular - Shallow Water Jogging

'Water running 'Vertical forces corresponded to 0.80 and 0.98 times the subject's body weight at the chest and hip level, respectively. Anteroposterior forces corresponded to 0.26 and 0.31 times the subject's body weight at the chest and hip level, respectively'

2010 – Haupenthal et al (healthy)

'Vertical peak and loading rate are lower in water, though the values are increased at higher cadences.

2012 – de Brito Fontana et al (healthy)

Stationary running sprint shows 17% decrease in cadence and 58% decrease in peak vertical ground reaction force (Fymax) when compared to dry land. Changes in cadence did not effect Fymax.

2015 – de Brito Fontana et al (healthy)

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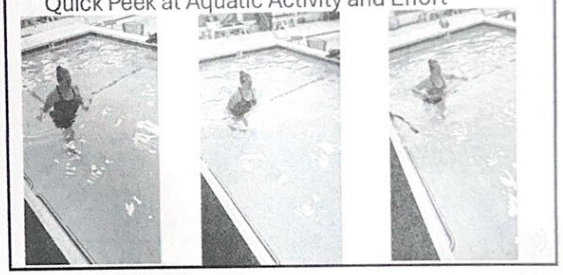
Quick Peek at Aquatic Activity and Effort



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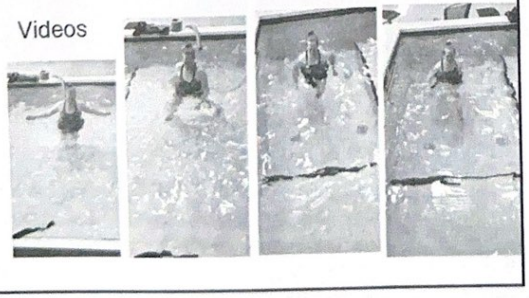
Videos



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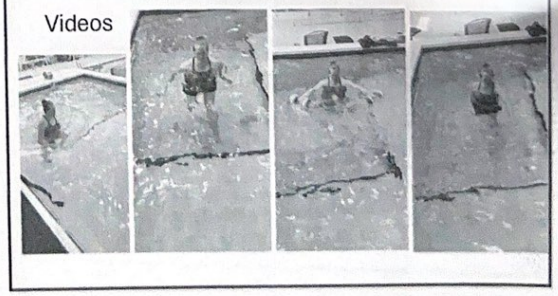

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Monitoring

Rating of Perceived Exertion – BORG Scale

6		
7	Extremely light	How you feel when lying in bed or sitting in a chair, relaxed
8		
9	Very light	
10		
11	Fairly light	Little or no effort
12		
13	Somewhat hard	TARGET RANGE!!!
14		How you should feel with exercise or activity.
15	Hard	
16		
17	Very Hard	How you felt with the hardest work you have ever done.
18		
19	Extremely Hard	
20	Maximal Exertion	Don't Work this Hard!

Rating of Perceived Exertion RPE – example

1	No Activity	
2	Light Activity	Breathing is easy
3		
4	Moderate Activity	Can still carry on a conversation
5		
6	Somewhat hard	Out of breath, can speak in sentence or two
7		
8	Very hard activity	Can only speak one word at a time
9		
10	Very very hard activity	Completely out of breath, unable to talk

Brennan Scale for Deep Water Running - Athletes

Rate of E	Descriptor	Cadence (b/m)	Sample Task
1	Very Light	~55-59	Light jog or recovery run
2	Light	60-69	Long Steady Run
3	Moderately Hard	70-79	5-10K Road Race
4	Hard	80-89	400-800M Race Speed
5	Very Hard	>90	100-200 Sprint

Talk Test for Cardiac Patient

Work at highest intensity possible that still allows you to carry on a comfortable conversation.

2016 – Alberton et al. (Validation of RPE in aquatic setting)

2016- Reed et al. and 2014 Persinger et al (talk test tool for intensity prescripti~)

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Cardiopulmonary Precautions

- Severe cardiac/pulmonary issues - aortic valve replacement, dyspnea, COPD, asthma
- Have asthma inhaler poolside
- Make sure patient passes cardiac talk test during exercise!!!!
- Keep O2 saturation at 90 or above with exercise.
- BP below 150/100 during exercise and also monitor for hypotension as she leaves pool.

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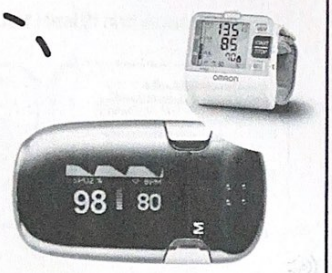
Monitoring



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Case Study - Monitoring

Dx – Aortic valve replacement, COPD, B knee OA

6 min walk test – 550 ft – with 3 breaks. Could walk maximum 48 sec before needing to take break.

BP - supine and sitting 140/80
BP - standing 110/70
(note drop in BP – orthostatic hypotension)

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Monitoring Examples

Looking good

Time for break (O2 sat low)

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Example Cardiovascular Training for Cardiac Compromised Patient

Activities vary based on condition of patient:
AROM (lower intensity); water walking (medium intensity); flutter kick with kickboard (higher intensity)

Warm up : 10-min (Borg scale 9-11/20 or RPE at 3/10)

Target zone: 20 min of Interval Training
2 to 8 min on (Borg scale 13-15 or RPE at 8/10)
1 to 2 min off (Borg scale 12)
repeat cycle
MONITOR USING TALK TEST

Cool down: 10-min (Borg scale 9)

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Example Cardiovascular Training for Athlete

Deep Water Running with belt and gloves

Warm up: 5-min (Brennan Scale level 2)

Target zone 1: 20-min (Brennan Scale level 3); cadence at 75 bpm

Target zone 2: 10-min (Brennan Scale level 4); cadence at 90 bpm

Cool down: 5-min (Brennan Scale level 2)

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Example – Cardiovascular Training General Population

Treading water in deep end

Warm Up: 10-min straddling noodle (Borg scale at level 11 -fairly light)

Target zone: 15-min without equipment (Borg scale at level 13 -somewhat hard) and cadence at 65 bpm

Cool down: 5-min straddling noodle (Borg scale at level 9 -Very light)

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Cardiovascular Health and Aquatics

- Explores the cardiovascular effects of long-term aquatic exercise in older adults in comparison to those who are either inactive or engaged in land-based/mixed training by measurement of micro- and macro-circulation.
- Flow Mediated Dilatation (FMD) was the primary studied outcome.

- Reported improvements in endothelial function at micro- and macro-circulatory levels, observing no differences between exercise modes (land or aquatic)
- Findings provide evidence for the role of aquatic exercise as a "shield" against CVD in older populations.
- Greater overall compliance with exercise in aquatic vs. land-based setting

2020; Konizakis M; Hunt B.E.; Woodward A

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Impact on Peripheral Arterial Disease

Although land-based exercise therapy is effective for reducing arterial stiffness and blood pressure in patients with peripheral artery disease (PAD), heated-water exercise therapy demonstrates greater benefits on vascular function.

- The greater improvements in muscular strength, time to onset of claudication, and exercise tolerance after heated-water exercise therapy may have clinical implications for improving quality of life in patients with PAD.

2020; Park SY, Wong A, Son WM, Pekas E.

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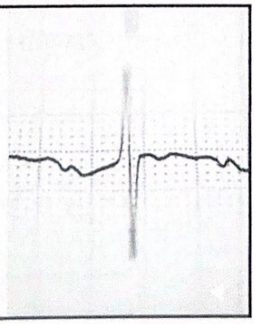
Effectiveness of Aquatic Circuit on CHD

- Water immersion can increase peripheral artery shear stress which may provide an additional stimulus to the endothelium during exercise.
- This study compared the effects of water-based circuit exercise training (WEX) and gym-based circuit exercise training (GEX) on vascular function in people with stable CHD.
- This study found that 12 wks of water-based circuit exercise training was well tolerated and improved vascular endothelial function in people with stable coronary heart disease.
- Scheer A., et al. 2023



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Effects of Aquatic Cardiac Rehab

- Investigation of the effects of water-based exercise on adults older than 60 years undergoing CR, comparing it to land-based exercise and a control group.
- Assessment of exercise capacity (VO_{2peak}), vascular function (flow-mediated vasodilation (FMD)), heart rate variability (HRV), and blood markers (Interleukins 6, 8, and 10, P-Selectin, ICAM, and High-sensitivity CRP) before and after CR
- Short-term water-based CR is an alternative to traditional land-based CR, improving VO_{2peak} and cardiorespiratory fitness among adults over 60 years undergoing CR after CI.
- 2024, Ksela J, Kafol J, Vasic D, Jug B

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Aquatic Exercise and Hypertension; Post-Exercise Hypotension

"There is a reduction in the vascular tone and peripheral vascular resistance..."

2007; Schega et al; 2008, Mourot et al.

Water density and hydrostatic pressure contribute to lower cardiovascular demand than land-based ex and orthopedic injury. This suggests the possibility of AE serving several individuals of different ages

2014, Yoo et al; 2015, Chien et al; 2014; Torres-Ronda et al

Water-based and aquatic exercises promote several cardiovascular alterations in healthy and cardiac patients. There is a greater increase in cardiac output and pulse pressure (PP) during water immersion exercises than those performed on land. These alterations are observed at rest and during exercise

2000; Gabrielsen et al; 2007; Schega et al; 200 Schmidt et al; 2008; Mourot et al.

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Other Clinical Pearls Related to Aquatics and CP Impact

- There are very few studies that have compared the chronic effects of AE and LE on blood pressure (BP) control. Junior et al (2019) observed that elderly hypertensive individuals trained in an aquatic setting had **lower baseline BP during the daytime.**
- Buonothai et al. (2020) research data show **a better lipid profile for AE compared to LE.**
- A study examining patients with stable chronic heart failure showed that AE has additional benefits to endothelial function because this type of exercise effectively increases the **basal level of plasma nitrates** (Mourot et al., 2009).
- Note: AE = Aquatic Exercise and LE= Land based Exercise

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Consider Additional CP Impact of Aquatic Exercise

- Water immersion decreases the vascular tone and total peripheral resistance (Mourot et al., 2008).
- Other exercise effects such as autonomic activity modulation, better baroreceptor reflex sensitivity, and endothelium-dependent vasodilatation are also important (Fadel, 2008).
- The mean maximum increases in HR, SBP and DBP with aquatic treadmill were significantly smaller than those of the land treadmill walking, better tolerance for stroke patients (Yoo et al., 2014).

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Cardiovascular and Strength Training

'Resistance and aerobic exercise performed either on land or in water can both improve exercise tolerance and muscular strength'

2007 –Volaklis et al (CAD)

High intensity deep water endurance ex provides increased cardiorespiratory responses and similar improvement in strength compared to deep water strengthening ex.

2015 – Kanitz et al (elderly men)

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Cardiovascular – Dosage

'Treatment duration of 60 minutes, frequency of three sessions per week and an intensity equivalent to 60%-80% maximum heart rate were the most commonly reported exercise components'

2009 – Perraton et al (fibromyalgia)

'Energy expenditure during a 40 minute aquatic exercise session met national recommendations for a daily moderate-to-vigorous bout of physical activity.

2014– Nagle et al (young adult women)

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Cardiovascular - Metabolic Syndrome

Combination of aquatic and land was better than either alone. Triglyceride and waist circumference was significantly decreased -HDL-C was significantly increased.

2013 – Yoo et al (elderly women with metabolic syndrome)

Aquatic exercise program improves metabolic profile, quality of like and physical activity level'

2014 – Cugusi et al (men type 2 diabetes mellitus)

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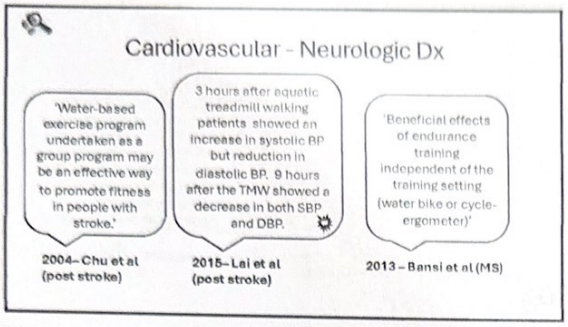

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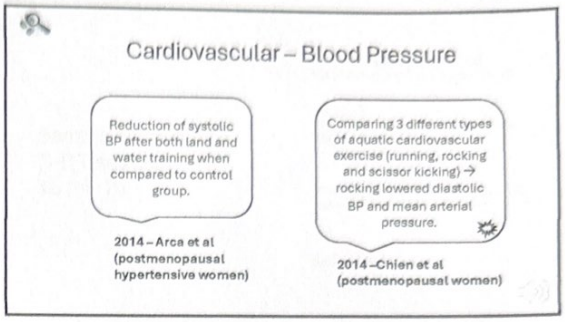

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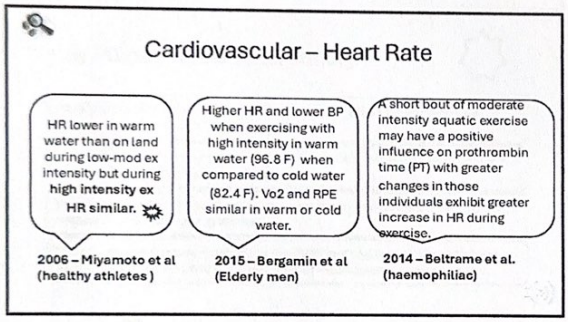

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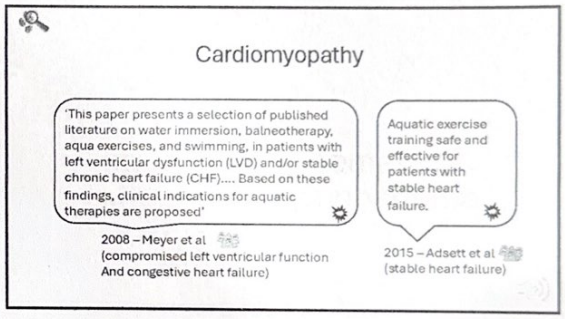

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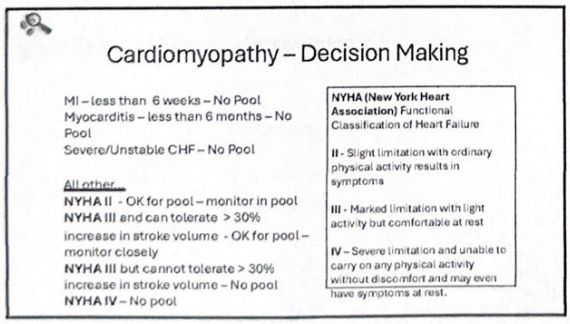

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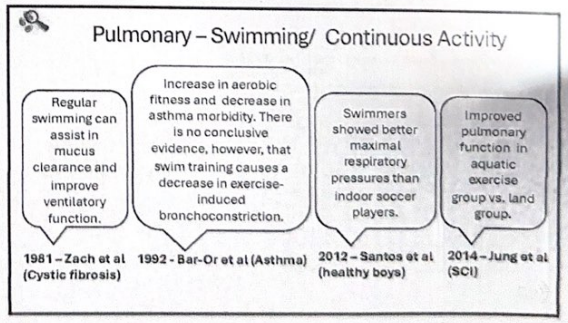

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Pulmonary Dysfunction

Water-based exercise training offers advantages over land-based training in improving endurance exercise capacity. Little evidence exists examining the long term effects of water-based exercise training'

2013- McNamara et al (COPD)

Water-based exercise and the aquatic environment is well accepted by people with COPD. High program adherence and completion noted and 89% of participants indicate they would continue with water-based exercise

2015 – McNamara et al (COPD with physical co-morbidities)

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Sample Aquatic C-P Treatment 45 min Rx

10 minutes warmup – stretching/ flexibility, nerve glides, walking FWI/ BW

20 minutes at target HR (60-70% of Max HR)

10 minutes: Interval – high intensity activity

30 second bursts (70-80% of max HR) followed by 1 minute recovery at 50-60% max HR

5 minutes cool-down

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Key Points - Cardiopulmonary

- Consider all cardiopulmonary related co-morbidities when choosing aquatic-based exercise
- Monitoring is absolutely critical. Teach self-monitoring and use tools for finite, objective readings, too. Document!
- Immersion alone – without exercise – creates a measurable effect on the cardiac and pulmonary systems
- The aquatic environment might be the BEST setting for cardiac rehab for patients with co-morbidities of arthritis or neurological impairments

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Aquatic Management of Edema and Lymphedema

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Types of Edema – Lymphedema

In the simplest terms, edema occurs when excessive fluid exists between cells in tissue.

- Types of edema (for this presentation)
  - Acute – from trauma or injury
    - Increased permeability of the capillary walls
  - Chronic – Venous insufficiency
    - Micro-circulation issues – phlebitis, venous value or mechanical
  - Chronic – Congestive Heart Failure
    - Systemic insufficiency (pump)
  - Chronic – Lymphedema
    - Lymphatic obstruction or impairment

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Aquatics and Lymphedema

- **A Review of General Treatment Exercise Principles for Lymphedema:**
  - Aquatic and Land-Based Exercise: Lymph flow is accelerated by pressure; in fact, **2-3 x more when moving**
  - Deep diaphragmatic breathing – causes **increased lymphatic drainage** at the thoracic duct (at the venous arch)
  - Evidence tells us that exercise is not effective for reducing limb size if it is just active or passive, needs to be mildly resistive – perfect for pool! (more effective with UE than LE) 2-3 x on land recommended. **Use the viscosity of the water for resistance!**
    - If the limb starts to swell with exercise, it is not handling the increased flow, need to work on decongestion and stabilizing limb volume first.

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Aquatic Therapy and Compression

- Acute considerations –
  - Consider the timing with the normal inflammatory process and weigh pro's and con's
  - Think about urgency of return to sport/activity and other tissue damage
  - Consider the advantages of both compression and unweighting
- Chronic considerations –
  - Challenges and benefits of co-morbidities in aquatic setting
  - Easier movement potential with compression benefits and no compression bandages
  - Opportunity for self lymphedema strategies plus simultaneous use of hydrostatic pressure
  - Possible opportunity for more motivating maintenance strategies with higher compliance, and more

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Critical thinking support

- Hydrostatic Pressure
  - Compression from distal to proximal
  - Increased benefit with movement
- Facilitated / easier movement in the water
  - Resistance of turbulence and viscosity
  - Opportunity for self management (lymph drainage) with compression impact
- Potential for client motivation and compliance improvement
  - Proven evidence of impact on pain, ROM, strength, endurance, and QOL

LONG TERM CLINICAL SUCCESS!

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Edema

- Significant decrease in ankle girth with immersion found in Division III players who sustained grade II ankle sprain.
  - **2001 – Geigle et al (collegiate athletes)**
- "Moderate-quality evidence that aquatic therapy in combination with land-based therapy improves functional outcomes, knee range of motion , and edema compared with land-based therapy alone."
  - **2015– Gibson et al (Knee or Hip Replacement)**
- "A specifically designed aquatic protocol is able to positively impact chronic leg swelling.."
  - **2017 – Gianesini et al (chronic LE edema)**

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Lymphedema

- Decrease fluid retention with Aquatic training.
  - **2001 – Jamison et al (breast cancer)**
- A significant immediate and insignificant long-term effect on limb volume was noted with Aqua Lymphatic Therapy.
  - **2010 – Tidhar et al (breast cancer)**
- 'Aqua lymphatic therapy group showed improvement with pain, arm disability and quality of life.
  - **2014 – Letellier et al (breast cancer)**
- Mod to vigorous intensity aquatic training increases functional capacity and QOL.
  - **2015 – Dionne et al (LE lymphedema)**
- Water-based and land-based care similar outcomes to improve lymphedema status.
  - **2018 – Yeung et al (lymphedema)**

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Lymphedema Videos

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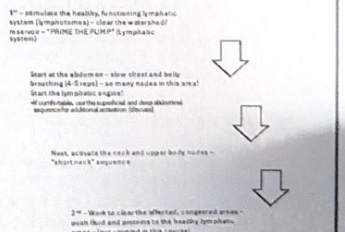
Treatment Sequence: Using the Evidence (Land and Aquatic)



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Aquatic Exercise Recommendations for Patients with Lymphedema based on Tidhar protocol for breast cancer survivors

- Walking walking walking of course!
  - Arm drag through water
  - Walk forwards and backwards for LE pumping and activation of different muscle groups
- Fist squeezes with arms in vertical and then self lymph massage – start proximal to "clear", then start further and further down the arm, moving fluid from distal to proximal
- LE strategies – need assistance and in supine floating position
- Deep breathing throughout treatment
- Turbulent exercises – aqua jogging unweighted or partially weighted, arm circles – multidirectional and multispeed

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Pull it all together – Case Study

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Hx/Dx: 49 yo; stage III ductal carcinoma – left breast; mastectomy 5 months ago; chemotherapy 21 weeks; radiation therapy 6 weeks. stage I lymphedema

CLOF: activity tolerance: 10 minutes; fatigue persists after resting/ sleep. Unable to work – previous occupation - teacher; difficulty with ADL's. Lives with husband.

PT problems:

1. CRF (cancer related fatigue – not relieved by rest)
   Poor Metabolic response to challenge – pulse oximetry drops to 88%
2. Restricted lymphatic cording and stage 1 lymphedema
3. loss of ROM L shoulder; impaired scapulohumeral rhythm
4. Generalized deconditioning and decreased strength in core and LE's – all major muscle groups

Release of lymphatic cording;
Opening axilla web;
Increasing Trunk and UE ROM

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Manual release with less pain than if done on land

More intensive and selective myofascial release

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More views of UE techniques

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Key Points – Edema and Lymphedema

- Remember that hydrostatic pressure is always at work while a body part is submerged in water
- Every therapist is able to help jumpstart the lymphatic system – even without advanced training and certification
- Movement plus manual lymph drainage strategies work best together
- Know your lymphatic specialists in your area and work together on compliance with programming for best long-term results
- Always know the SOURCE and differential diagnosis of of edema/ lymphedema before deciding on a course of treatment

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